Operational Evolution Plan (OEP) Modeled System Performance Update

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Over the past several years, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) has worked closely with the Federal Aviation Administration (FAA) to assess the potential benefits of planned improvements to the National Airspace System (NAS).

The NAS is a very dynamic system, constantly undergoing changes. Over-time, enhancement plans are modernized, traffic schedules change, and future demand forecasts are updated to reflect differences in the system. As these changes take place, CAASD updates its benefit assessment in order to have the most accurate analysis available for the FAA. This briefing touches upon the current state of the system, describes changes in future demand forecasts, and then updates past OEP benefit assessments using the most up-to-date information available. Specifically, OEP v8.0 is analyzed using a March 2006 schedule and the FAA's 2005 Terminal Area Forecast (TAF) which was released in February 2006.

Benefits are presented on a NAS-wide as well as airport specific basis. In addition to analyzing future performance based upon point estimates of demand from the most current TAF, CAASD also undertook an effort to measure potential variability in future performance. Future performance ranges are calculated and based upon estimated levels of demand given variations in historic traffic growth at each airport.

Current System Performance

Note: All acronyms are defined in the Glossary at the end of this document.

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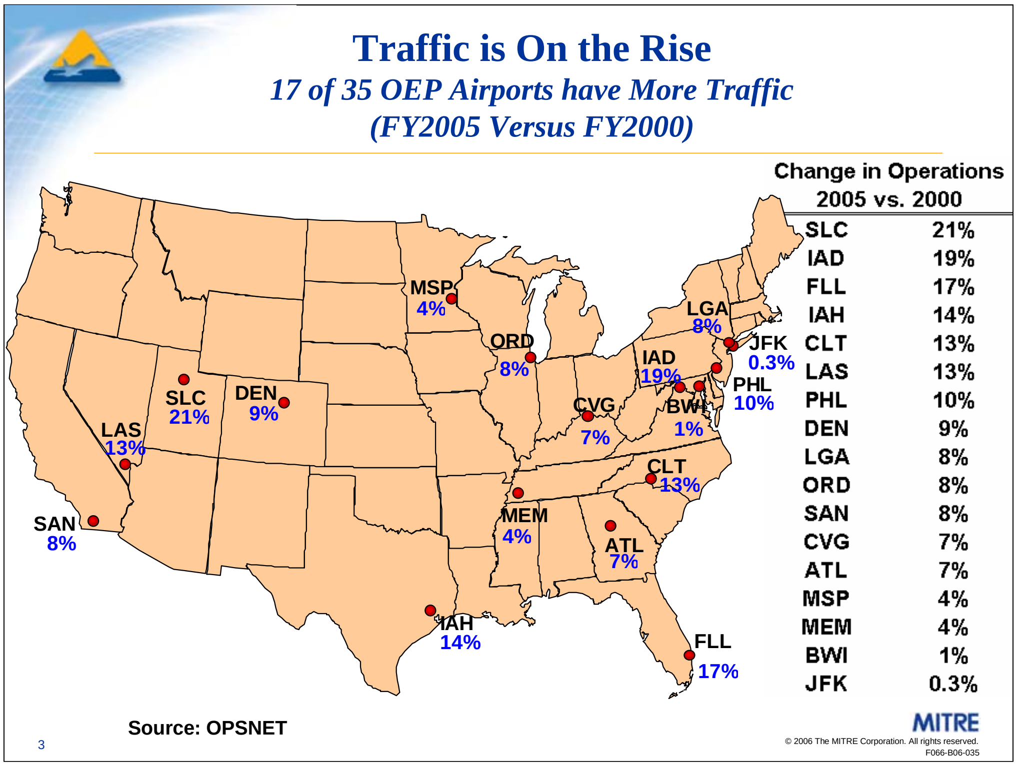
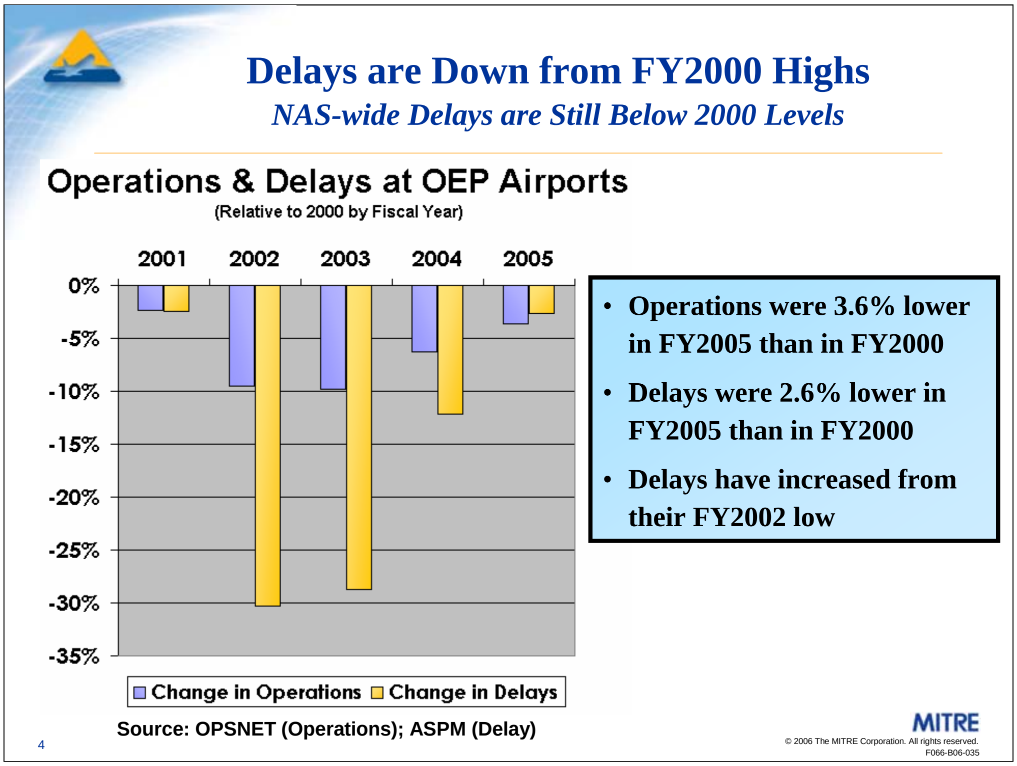
This section will briefly summarize the current state of the NAS. It documents changes in airport and en route traffic levels as well as delays at the 35 OEP airports in FY2005.



Delays in 1999 and 2000 were significant across the NAS. High levels of traffic demand and excessive delays prompted the FAA to capture in one document its many enhancement plans slated to improve the system. The OEP was developed to satisfy the need to document, communicate, and track capacity improving enhancements in one location. Because delay levels experienced in 1999 and 2000 were the impetuous for development of the OEP, the year 2000 is often used as a reference point to compare future performance.

Traffic levels in FY2005 exceeded those of FY2000 at 17 of the 35 OEP airports. This compares to only 13 airports in FY2004 that had more traffic than in FY2000. The airports with higher levels of traffic are shown on the map along with the amount of additional traffic shown as a percentage. Differences in traffic ranged from 0.3 percent at JFK to as much as 21 percent additional traffic at SLC.

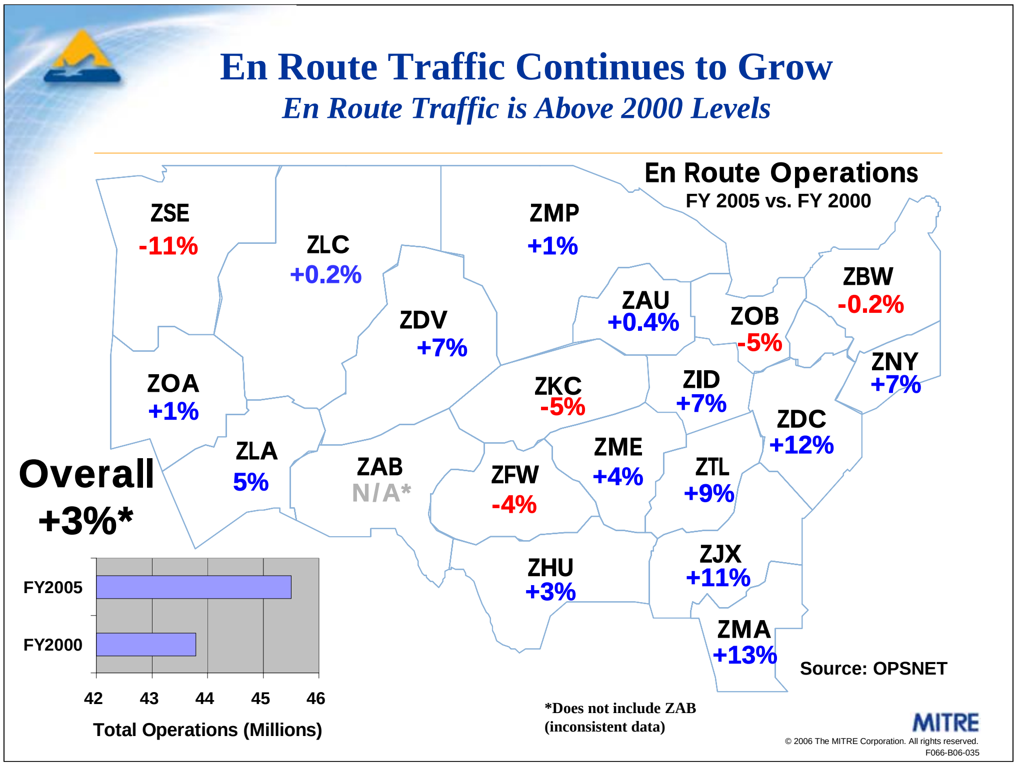
The system is still undergoing rapid change as airlines enter and emerge from bankruptcy, enter and exit markets, and modify their aircraft fleets. Some airports have lost significant amounts of traffic as airlines cease hubbing operations, while other airports have significant increases in operations as flights are shifted out of the old hub airport. These changes are watched carefully in order to estimate their impacts on future performance.



Although traffic was up at 17 of the 35 OEP airports in FY2005, across all 35 OEP airports together it was down approximately 3.6 percent in FY2005. At the same time, delays were down 2.6 percent in FY2005 compared to FY2000. The bar chart above documents changes in operations and delays between FY2001 and FY2005, all compared to FY2000. Blue bars indicate changes in operations, while yellow bars indicate changes in delay.

Between FY2000 and FY2005, delays at the 35 OEP airports were at their lowest level in FY2002, with a nearly 30 percent decrease in delay resulting from an approximately 10 percent decrease in operations. Performance in FY2003 was almost identical. By FY2004, delays were returning with only 12 percent less delay resulting from a 6 percent decrease in operations.

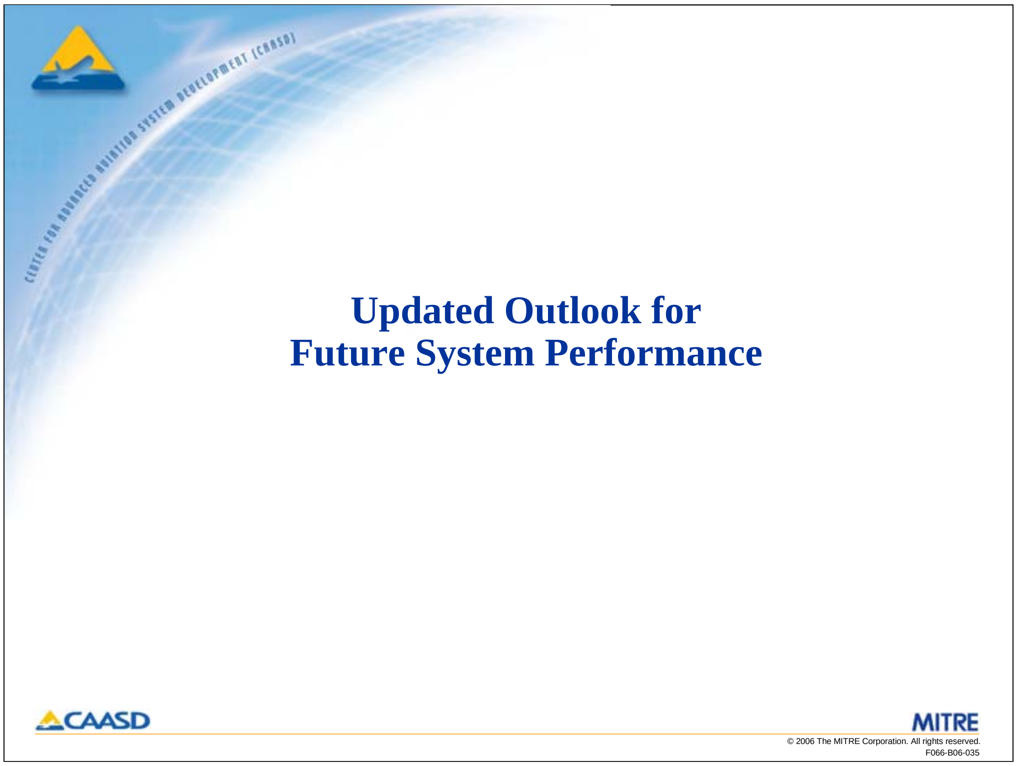
At airports where demand is close to capacity, delays often drop at a faster rate than operations because delay growth is non-linear compared to increases in demand. At the same time, as demand returns, delays often grow at a much faster rate. This is caused by the non-linear behavior of delays, as well as by a natural system response to delays, such as an airline changing scheduled block times to take advantage of more efficient operations.



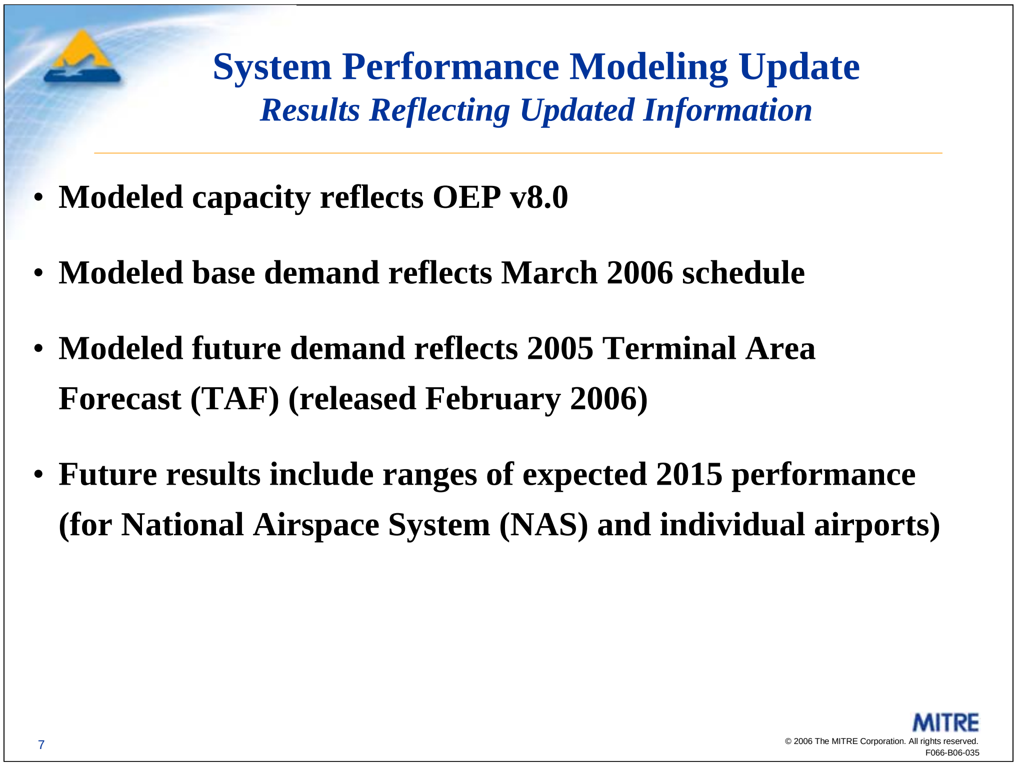
While demand is down overall at the OEP airports, en route traffic is up across much of the country. Some locations increased by less than one percent, while others had as much as 13 percent more traffic. In FY2005, there was approximately three percent more traffic in NAS-wide en route operations relative to FY2000. This compares to a one percent increase in operations in FY2004 compared to FY2000.

Higher levels of en route operations, with decreased airports operations, is possible because of the longer stage lengths of today's flights. Since 2001, significant numbers of short-haul flights have been removed while long-haul flights have increased significantly. The long-haul flights increase the average length of the routes being flown, consequently, increasing the number of centers that are being traversed overall.

The data above does not include ZAB due to data reporting issues in FY2000.



This section focuses on changes to our analysis approach as well as changes to future demand estimates as reported in the FAA's TAF.



Updating the prior system performance analyses required several pieces of information to be brought up-to-date. Airport capacities in 2015 assume improvements included in OEP version 8.0. The 2004 airport capacity benchmark report, used in the prior analyses, was based on an earlier version of the OEP. Because of extensive changes in OEP version 8.0, most airports needed updated capacity modeling to be performed.

Modeled demand is based on a day in March 2006, accounting for recent schedule changes, such as the discontinuation of service by Independence Air and depeaked schedules by Delta Airlines. All else being equal, changes in demand patterns, cities served, and traffic levels can produce very strong responses in performance modeling results so it is vital to track changes in scheduled demand whenever possible.

Future demand assumes growth consistent with the FAA’s TAF, which was released in February 2006. This TAF is different from previous releases as it was the FAA’s first attempt to incorporate Very Light Jets (VLJs) into their forecast, which did have a significant impact at some OEP airports.

In addition to modeling performance based upon the TAF, this analysis also modeled ranges of expected performance in 2015, both on a NAS-wide basis and on an airport basis. This helps provide a sense of how much uncertainty exists in the modeled performance estimates given ranges of potential demand.

Forecast Changes

Difference Between 2004 and 2005 TAF in 2015

Airport	TAF 2004	TAF 2005	% Change
ATL	1,279,975	1,140,615	-11%
BWI	448,306	401,127	-11%
CVG	699,692	509,511	-27%
DTW	754,909	671,847	-11%
IAD	923,001	647,107	-30%
LAS	717,257	861,482	20%
PIT	319,956	284,571	-11%
SLC	600,703	513,754	-14%

Note: 2005 TAF as of March 20, 2006
2004 TAF as of March 10, 2005

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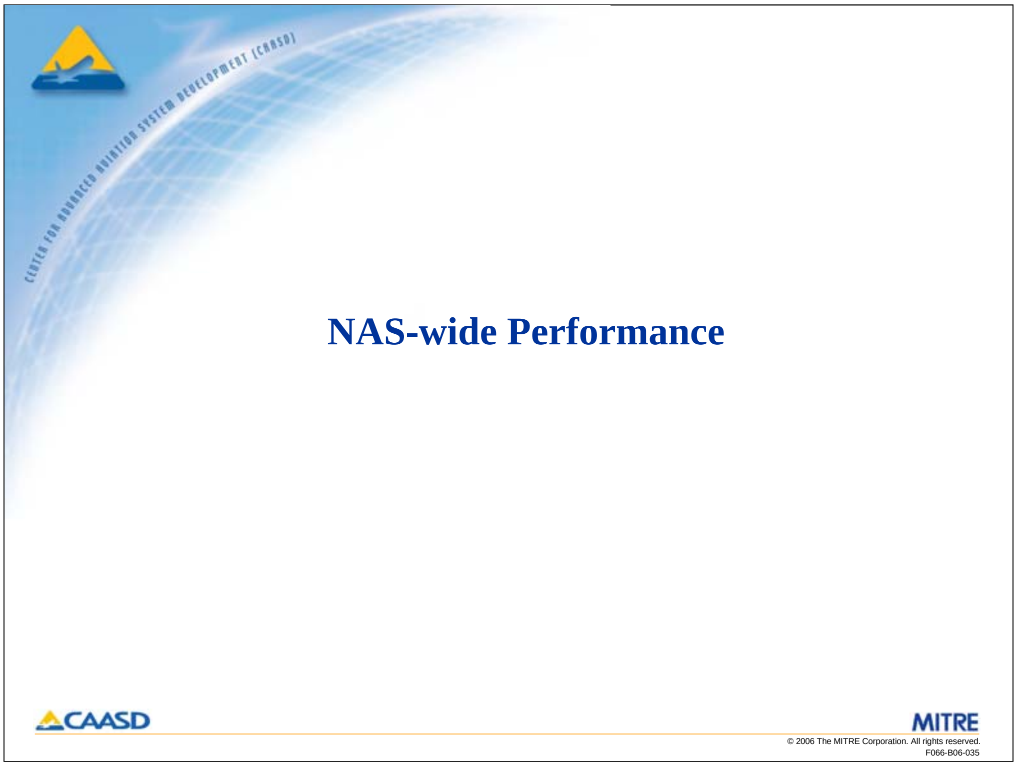
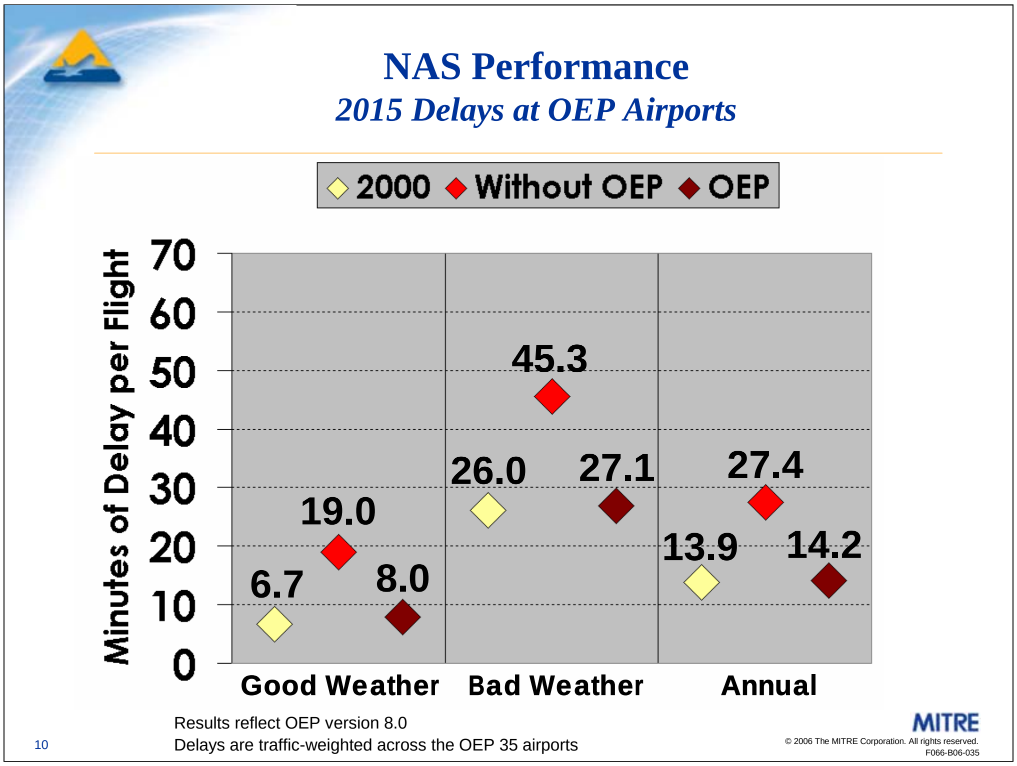
The table above shows the number of operations forecast by the 2004 and 2005 TAFs for the year 2015, as well as the percent change between the forecasts. Seven airports have decreases in 2015 forecast operations of 10 percent or more in the 2005 TAF. ATL, CVG, and SLC had their forecasts adjusted downward due to schedule changes by Delta. BWI's forecast was lowered due to lower than expected enplanements in 2005. DTW's forecast was adjusted due to schedules changes by Northwest. IAD's forecast was adjusted due to the discontinuation of service by Independence Air. PIT's forecast was lowered due to schedule changes by US Air.

Only LAS had their forecast increased by more than 10 percent in the 2005 TAF. This was partly due to the inclusion of VLJs in the TAF forecast, and partly due to increased service by Southwest and US Air.

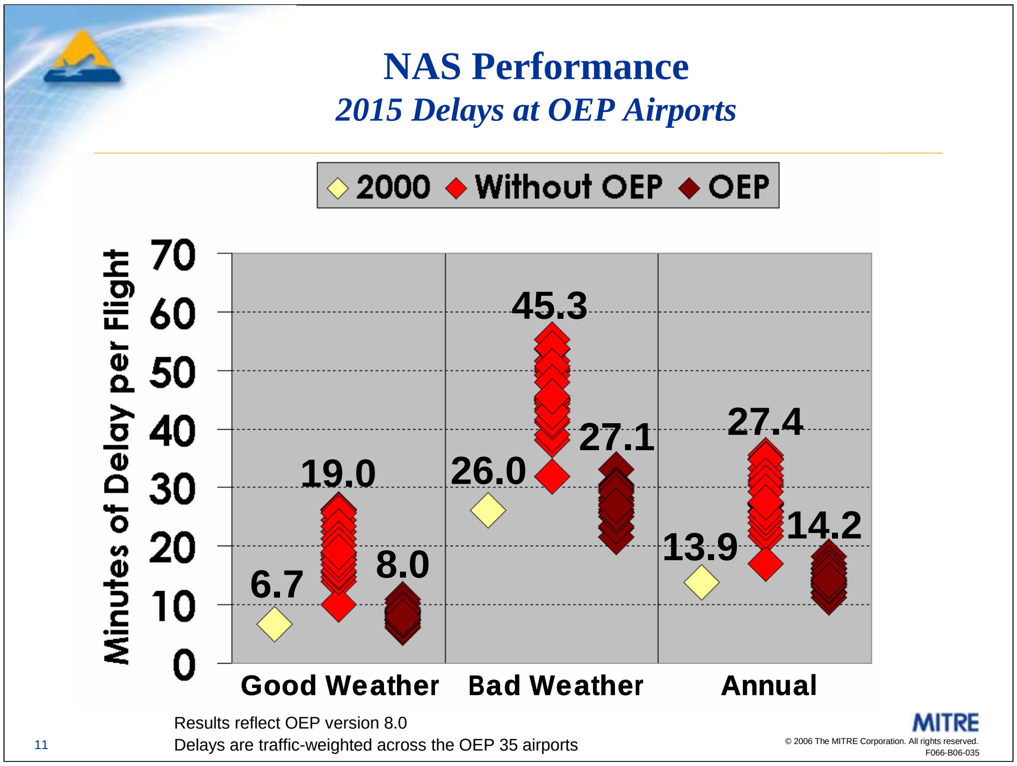


This section focuses on NAS-wide performance given updated demand and capacity estimates.



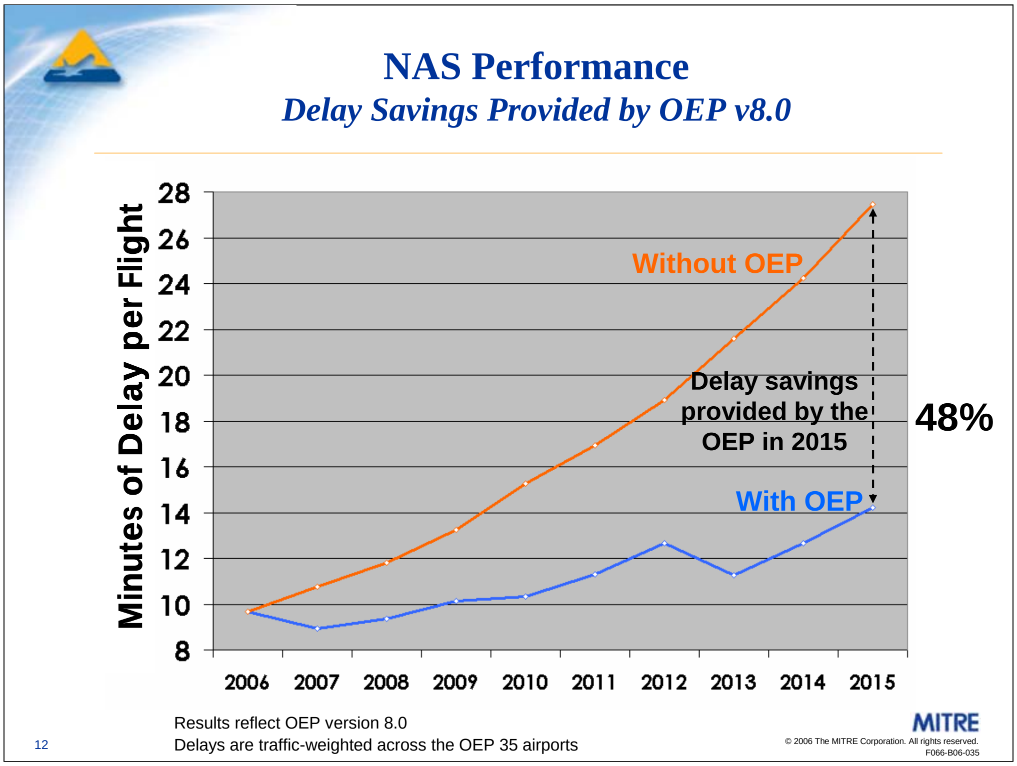
The chart above shows average minutes of delay per flight in good weather, bad weather, and on an annual basis for several different scenarios. The gold diamonds show the actual delays realized in FY2000 as recorded in historical data by the FAA in their ASPM data system. The red diamonds show the levels of delay that could be possible by 2015 if no capacity improvements were implemented beyond what exists in the system today. In reality delays would never really reach these levels as the system would naturally respond by limiting the amount of traffic in the system at high delayed airports. However, this analysis does not account for or value the removal of these flights in order to more easily compare results across scenarios. The maroon diamonds show what delays are possible by 2015 after the OEP is fully implemented. Delays are expected to be about the same in 2015 as they were in 2000 on an annual basis, with delays in bad weather worse than delays in good weather.

It is important to note that this analysis does not attempt to ***predict*** actual levels of delay in the system at various points in time. The analysis is used to understand how the system is performing compared to a baseline case and to look for problem areas in the future. However, NAS-wide modeling technology today does not allow for precise modeling of all aspects of the system, including airline and ATM responses, passenger behavior, fuel prices, etc. Due to these limitations, these results should not be considered predictions of actual delay levels but should be used as indicators of system performance.



The NAS is undergoing rapid changes as airlines restructure to accommodate changing business needs. These rapid changes often cause sharp increases and decreases in total airport operations over short periods of time. For example, the introduction of Independence Air into IAD produced a large increase in operations at the airport over a very short period of time. When Independence Air ceased operations at IAD about a year and a half later, a rapid decline in operations occurred. These abrupt changes often cause problems when forecasting future operation levels and future performance as the baseline operations the results are based upon are dramatically changing. To address this problem and to better understand how much variability may exist in future performance estimates, this analysis undertook an effort to measure performance given potential ranges of airport demand.

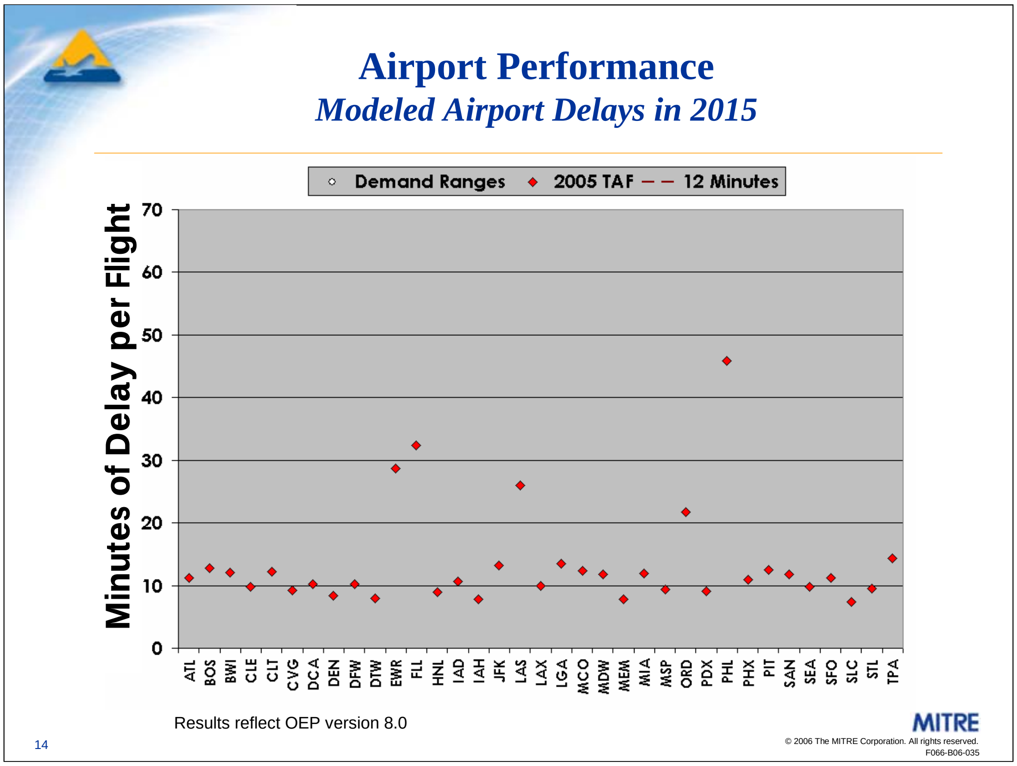
To measure future performance variability, historical growth data was analyzed at each of the 35 OEP airports. Using long-term growth trends measured at each airport between 1976 and 2005, 22 different demand scenarios were produced. The result is a set of 23 possible outcomes in 2015 (2005 TAF plus 22 other demand scenarios), each represented by a red diamond (without OEP) and a maroon diamond (with OEP) in the above chart. Where the point estimate indicated that *annual delays* would be about the same in 2015 as they were in 2000, these results indicate that delays could be as low as 11 minutes or as high as 18 minutes depending on the level and characteristics of the demand in the system in 2015. This study also indicates that the amount of variability without the OEP is much larger than with the OEP. This is because as demand approaches capacity the system become more unstable and delay growth is highly non-linear, causing more variability.



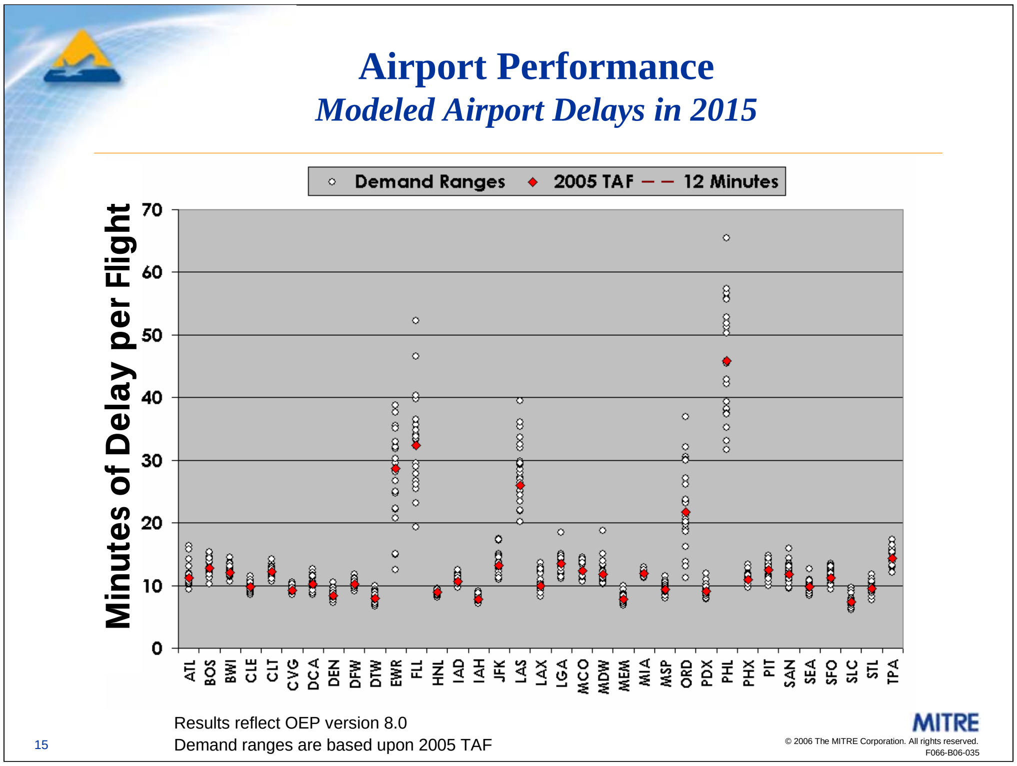
This analysis also explored how NAS-wide delay may change over-time as improvements are implemented and traffic levels increase. The chart above shows how delays are expected to change year by year as the OEP is implemented and it compares that to delay levels without improvements.

The orange line on top shows how delays would grow with today's capacity and no additional improvements. Delays would grow quickly, exceeding 14 minutes per flight by 2010. The blue line on the bottom shows lower levels of delay and a slower rate of growth as OEP improvements are put into place. The difference between the two lines shows the benefit of implementing the OEP: a 48 percent delay savings by 2015.

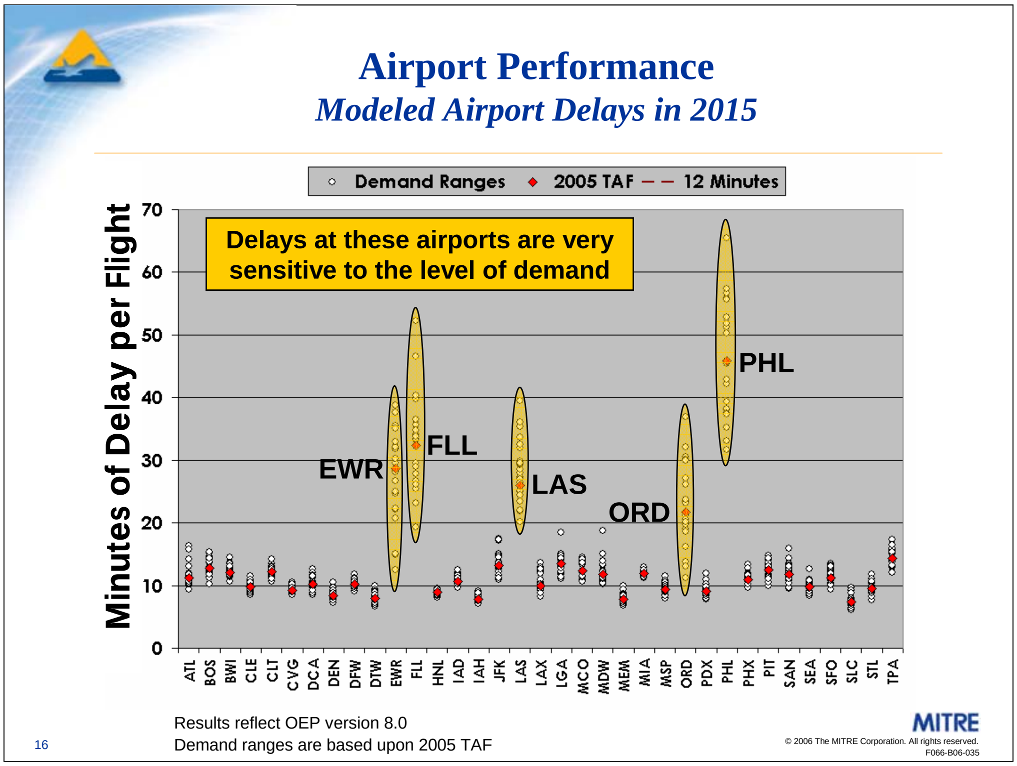
The previous section focused on NAS-wide performance estimates. This section of the briefing will explore airport specific results and how each airport is likely to perform given improvement plans and various growth scenarios.



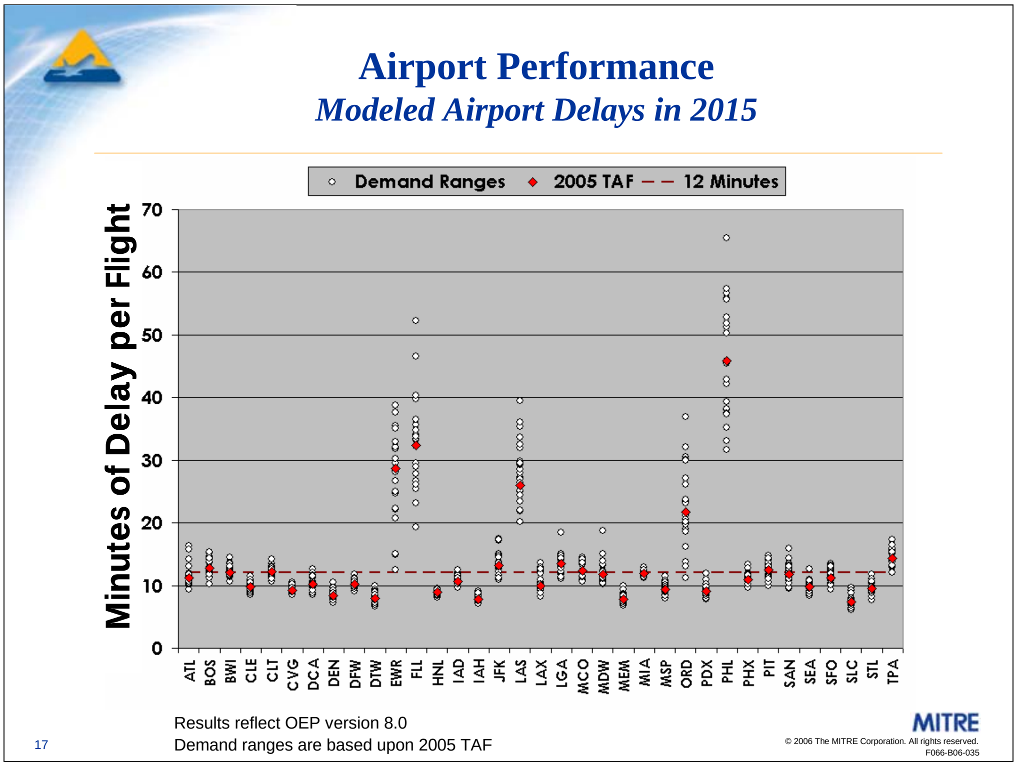
The chart above shows the average minutes of delay per flight modeled at each airport assuming 2015 capacity and demand based upon the 2005 TAF. Although the average delay per flight on a NAS-wide basis was modeled at 14.2 minutes, some airports (such as MEM) had significantly lower levels of delay, while others (such as FLL) had delays much above the NAS-wide average. These results indicate that although the NAS-wide average delay is about equal to that experienced in 2000, some airports may still have significant delays in 2015 while others may not.



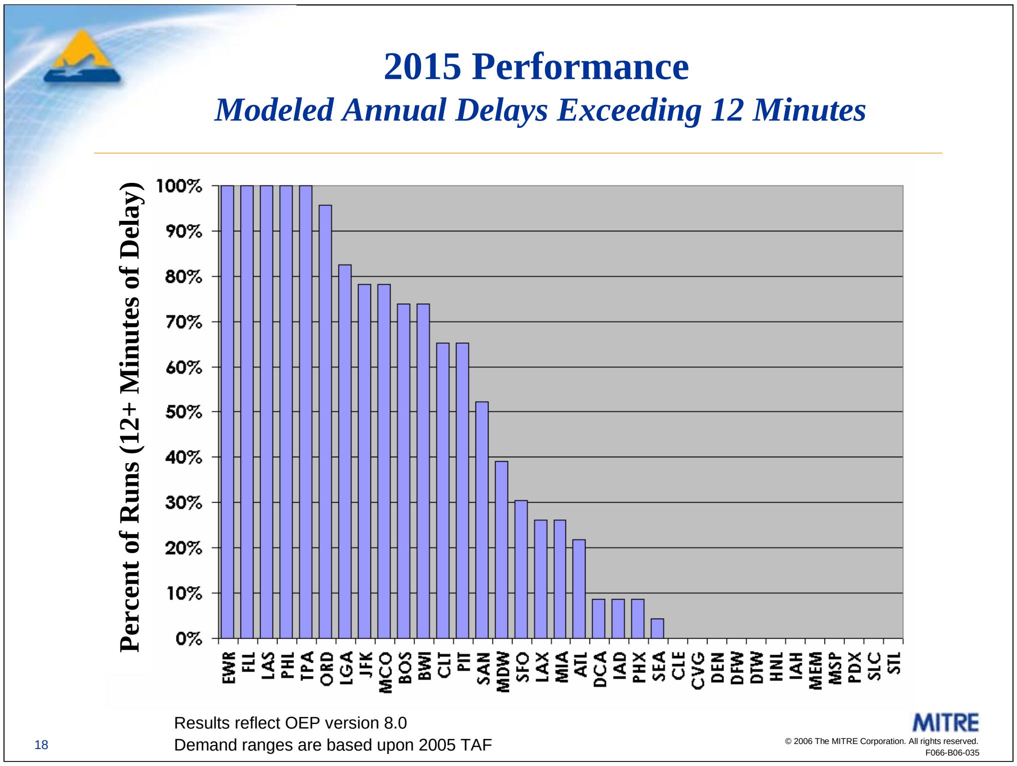
This chart is similar to the previous chart in that it shows the average minutes of delay per flight modeled at each airport assuming 2015 capacity and demand based upon the 2005 TAF (red diamonds). However, in addition to the 2005 TAF results, each white circle represents the result of using one of the 22 sets of modeled demand that are based upon observations of historical growth. This gives an idea about how much variability may exist airport to airport. Some airports such as CVG and HNL have very tight delay ranges with little variability. Other airports, such as FLL have much larger ranges of variability and seem more sensitive to different demand levels.



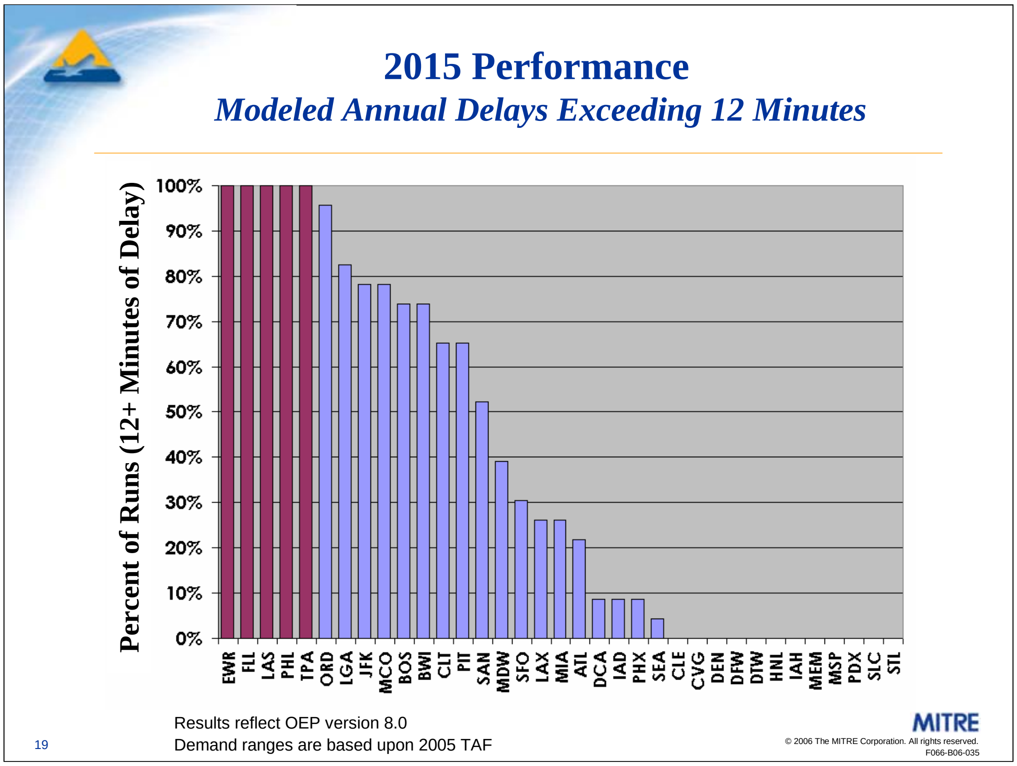
As discussed on the previous page, some airports have much larger levels of delay variability appearing in their results. EWR, FLL, LAS, ORD, and PHL are examples of airports that have very wide ranges of delays. Demand at each of these airports is expected to be at or near the airport's capacity during much of the day. Since delays grow exponentially with demand, they are very sensitive to the level of demand at these airports. When demand is low, delays drop significantly. At the same time, as demand levels increase, delays can grow very quickly, causing higher levels of variability.



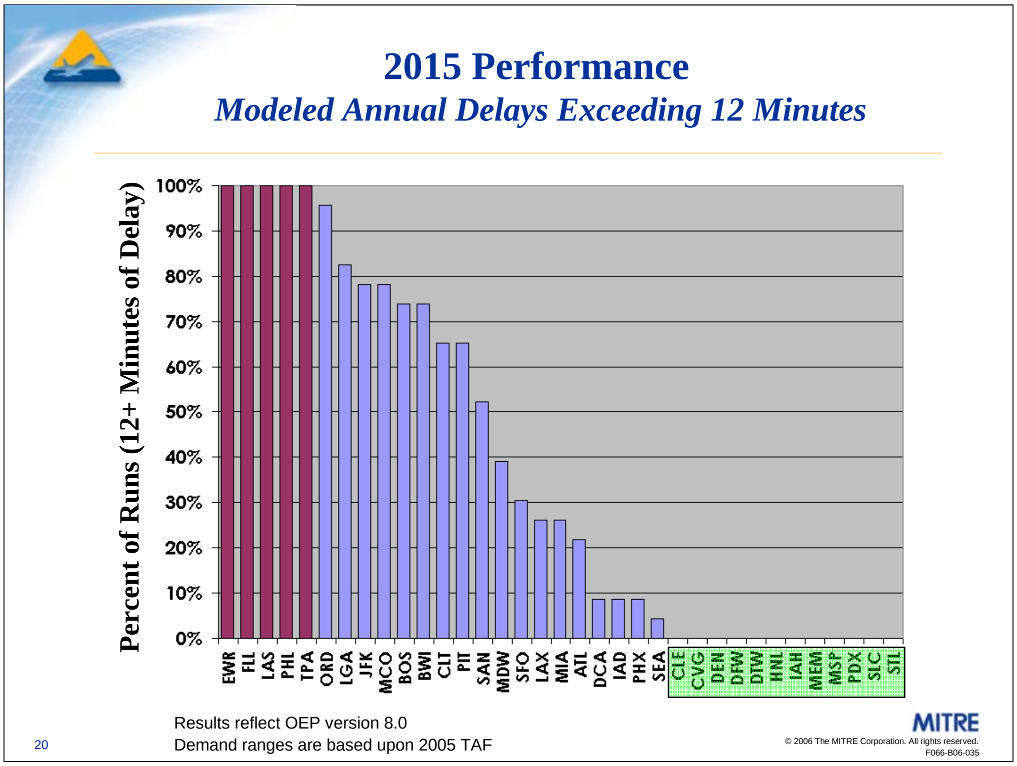
In past results, airports with delays of 12 minutes or more per flight were identified as airports that may need additional capacity in the future. However, these airports were identified using only a single delay estimate based upon demand from the most current TAF. For this analysis it is now possible to measure a range of possible delays given potential ranges in demand. With point estimates, airports were either above or below 12 minutes. With performance ranges there is a better sense of the uncertainty in the performance of the airport. The chart above graphically indicates where the 12 minutes of delay per flight point is. Some airports are always above the line, others are always below, and still others straddle the 12 minute mark.



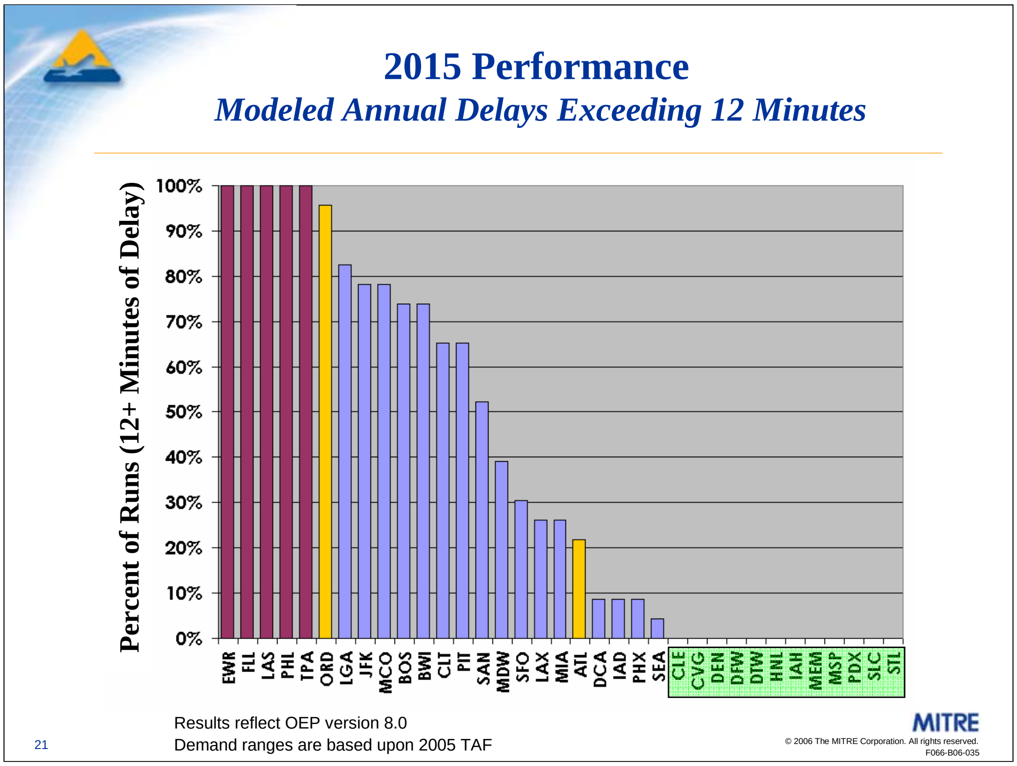
Where previous results would indicate whether or not an airport exceeded 12 minutes of delay per flight for the given TAF, the new set of results provide a capability to describe how often this 12 minute mark is exceeded. The chart above shows the *percentage* of the 23 modeled scenarios where an airport exceeds 12 minutes of delay per flight in 2015. The modeling results found that some airports always exceeded this limit, regardless of demand levels modeled, while others never did. The OEP airports are listed along the bottom of the chart with the airports to the left side exceeding 12 minutes of delay more frequently than the airports to the right.



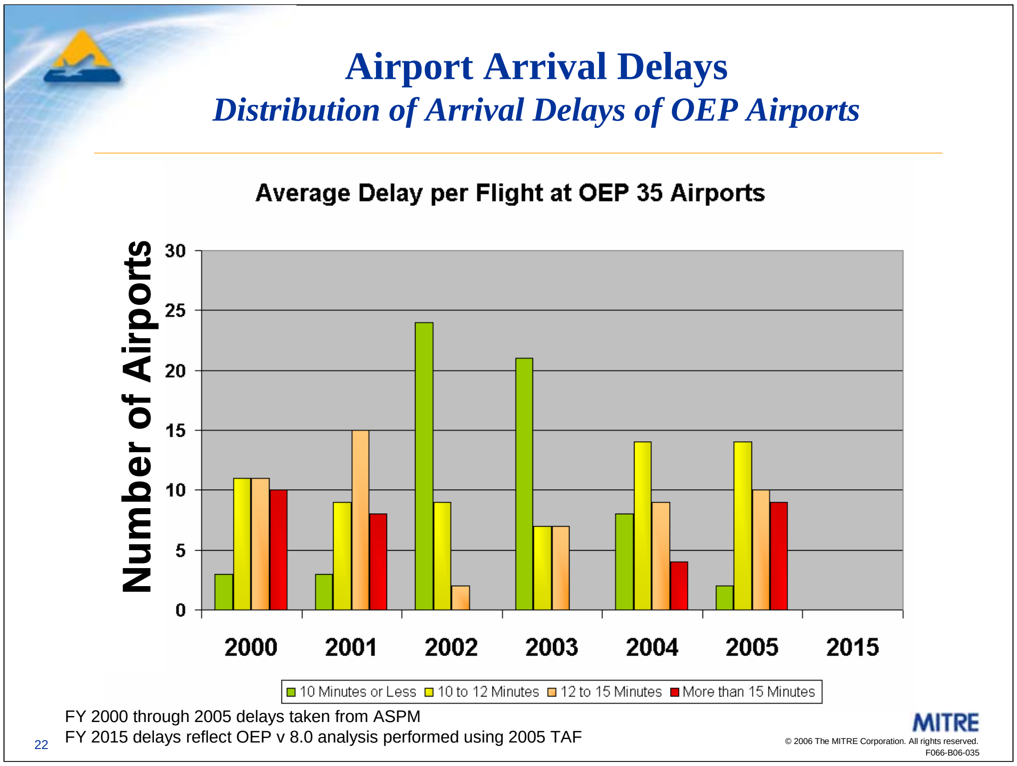
Five airports—EWR, FLL, LAS, PHL, and TPA—exceed 12 minutes of delay in each of the 23 runs (100% of the time). The results revealed that these airports may need additional capacity in the future as regardless of the demand levels that were modeled, they had significant delays.



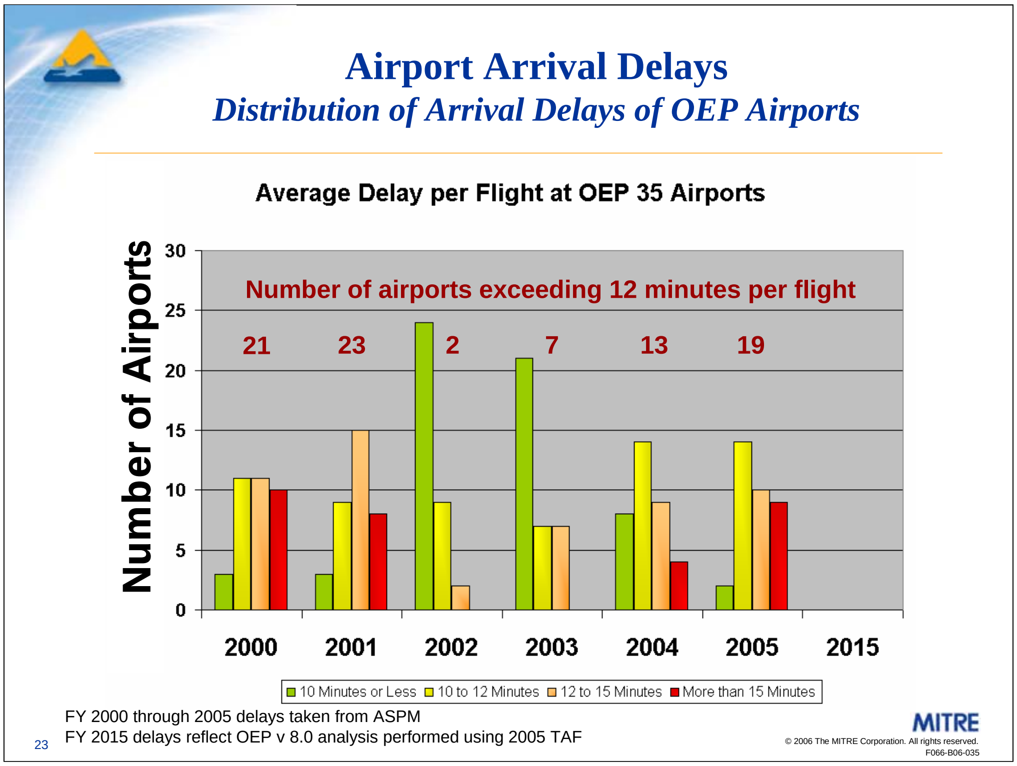
On the other hand, twelve airports—CLE, CVG, DEN, DFW, DTW, HNL, IAH, MEM, MSP, PDX, SLC, and STL—did not exceed 12 minutes of delay in any of the model runs. These airports would not be expected to need additional capacity as even in the worst-case modeled scenario delays were not above the 12 minute threshold. However, if demand grows significantly *differently* from how it was modeled in this analysis, there is a possibility for higher levels of delay to occur.



The remaining 18 airports are the most interesting. Delays at these airports exceed 12 minutes in some, but not all, of the model runs. At ORD, for example, one model run showed a chance that delays may remain below 12 minutes in 2015. At ATL, simply modeling the TAF demand would have indicated that delays will remain under 12 minutes; however, the ranges of demand show that even with the new runway, ATL is modeled to exceed 12 minutes of delay in around 20 percent of the runs. These 18 airports may or may not need additional capacity depending on how much demand actually materializes and how airlines respond to the changing environment. These airports should be watched more closely as time goes on as each has shown a sign that delays above 12 minutes per flight is possible. More research is also necessary to determine what percentage of model runs exceeding 12 minutes per flight should be a concern.



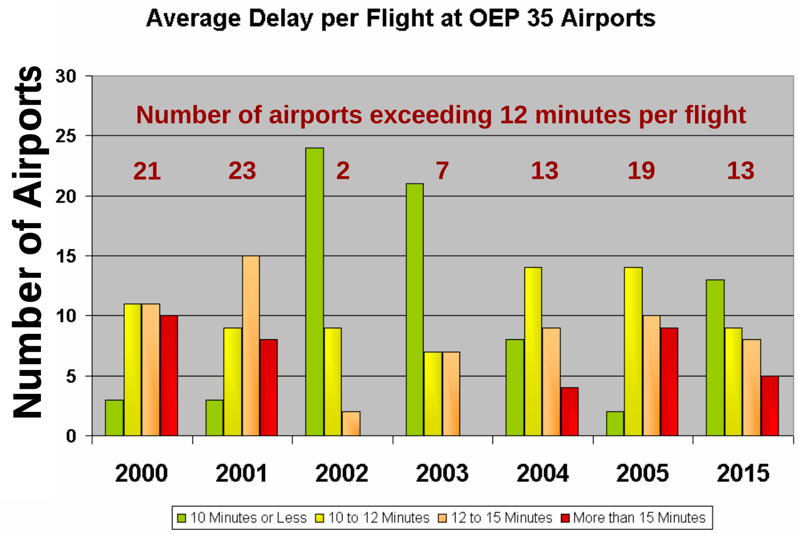
In addition to NAS-wide average delay per flight and airport specific delays, the distribution of delays is also of interest. The chart above shows how the distribution of annual delays among the OEP 35 airports has changed from 2000 to 2005. The chart shows how many of the OEP airports experienced delays of 10 minutes or less (green), 10 to 12 minutes (yellow), 12 to 15 minutes (orange), and greater than 15 minutes (red). This data is historical data as measured by the FAA's ASPM system.



In 2002 and 2003, following a drop in traffic demand, no airports experienced an average delay per flight of more than 15 minutes. Since that time the number of airports experiencing delays above 15 minutes per flight has grown. In 2005 nine airports averaged delays above 15 minutes per flight compared to 10 airports in 2000. In 2000, 21 airports had at least 12 minutes of delay per flight. That number dropped to two as traffic levels decreased in 2002, but has risen back to the point where 19 airports exceeded 12 minutes in 2005.

Airport Arrival Delays

Distribution of Arrival Delays of OEP Airports



FY 2000 through 2005 delays taken from ASPM
FY 2015 delays reflect OEP v 8.0 analysis performed using 2005 TAF

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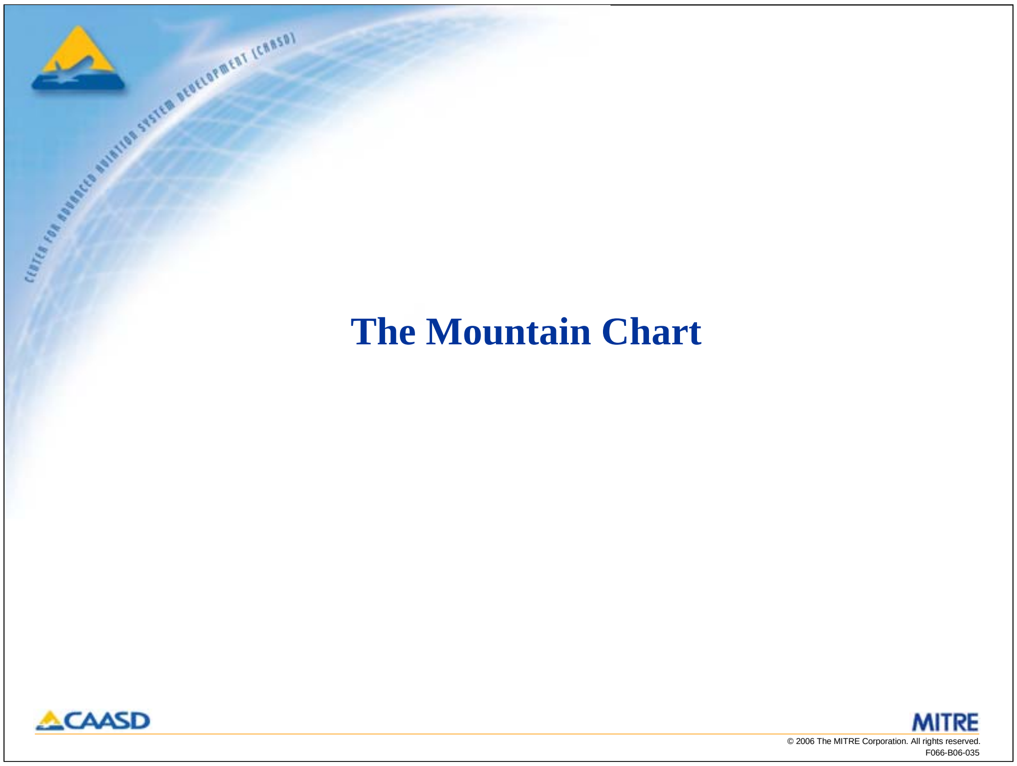
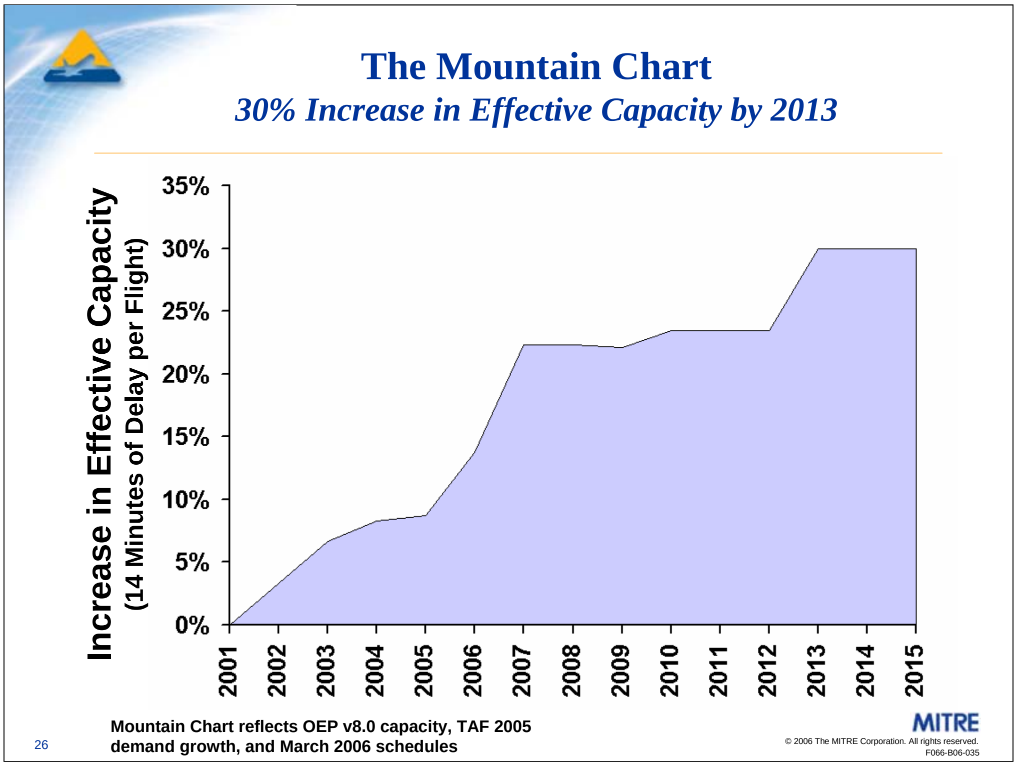
Modeling results based upon the 2005 TAF and assuming OEP version 8.0 improvements indicate that by 2015, 13 airports may experience 12 minutes of delay or more. This is a smaller number of airports than seen in both 2000 and 2005.



This section reports the results of an analysis that measures ‘Effective Capacity’. *Effective Capacity* is the level of traffic that can be accommodated in the NAS at a fixed level of delay. It is dependent upon the delays and demand expectations at each airport, in combination with the implementation of specific capacity improvements over-time.

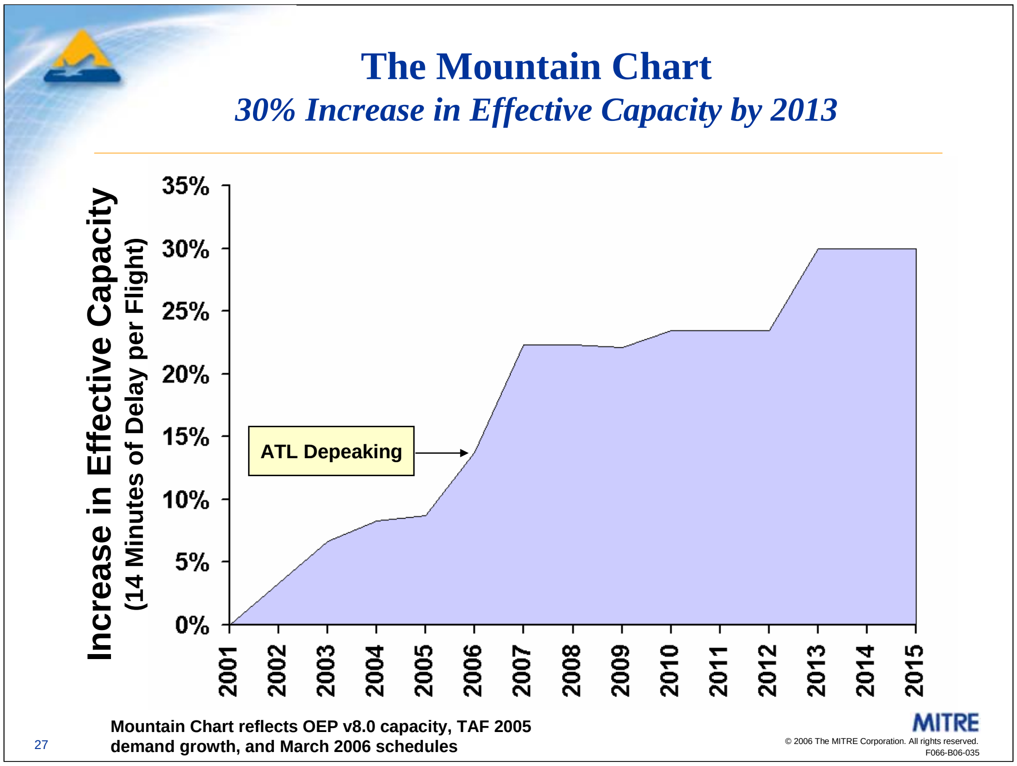
Effective capacity is a means by which one may measure the contribution of all improvements, in combination, to the performance of the NAS as a whole. The Mountain Chart documents the increase in Effective Capacity, year by year, as a percentage of *additional traffic* that can be handled given capacity improvements provided by the OEP. For example, if 100 flights can be handled at a set delay level in the baseline and 130 flights can be handled at the same level of delay given improvements provided by the OEP, then that would be indicated as an improvement of 30% Effective Capacity.



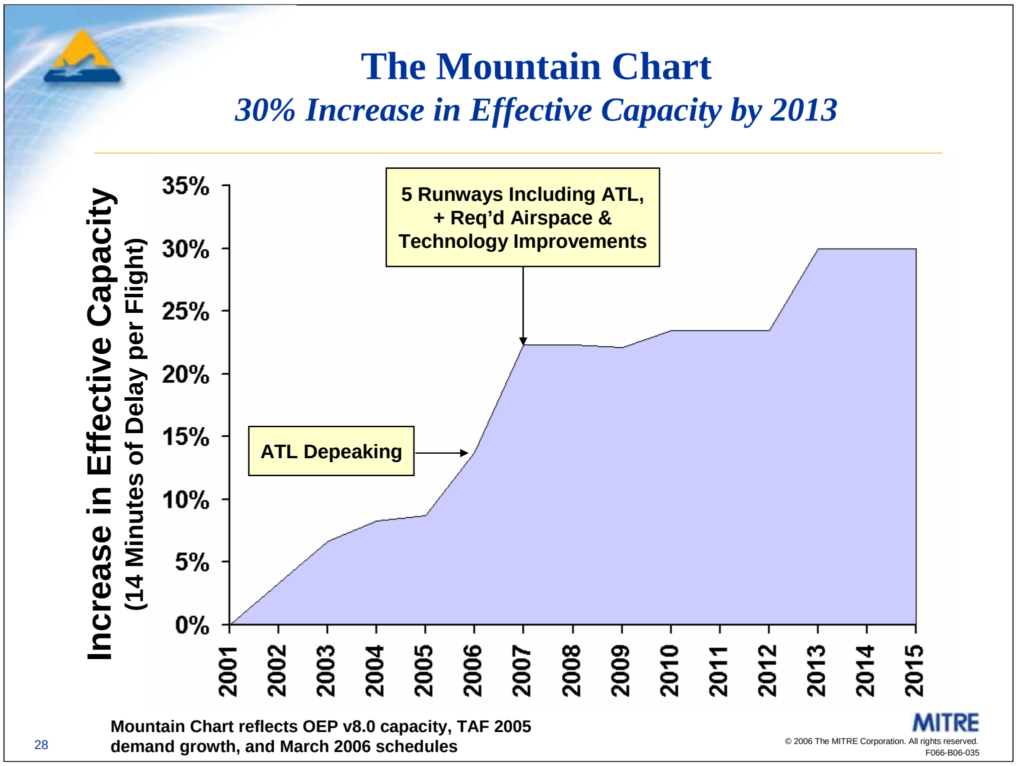
Of particular interest to the OEP is the amount of capacity being added to the system given all improvements in combination. Over the years, the Mountain Chart has indicated how much demand the system can accommodate at a fixed level of delay: 14 minutes per flight. The Mountain Chart shows that given planned OEP improvements, Effective Capacity will increase by 30 percent by the year 2013. That is, 30 percent more traffic can be handled in 2013 at 14 minutes of delay per flight than could have been handled in 2001.

The increase in effective capacity is not linear, however. It grows over-time as improvements are implemented. The following pages point out when some of the more major improvements are taking place and their impact on Effective Capacity.

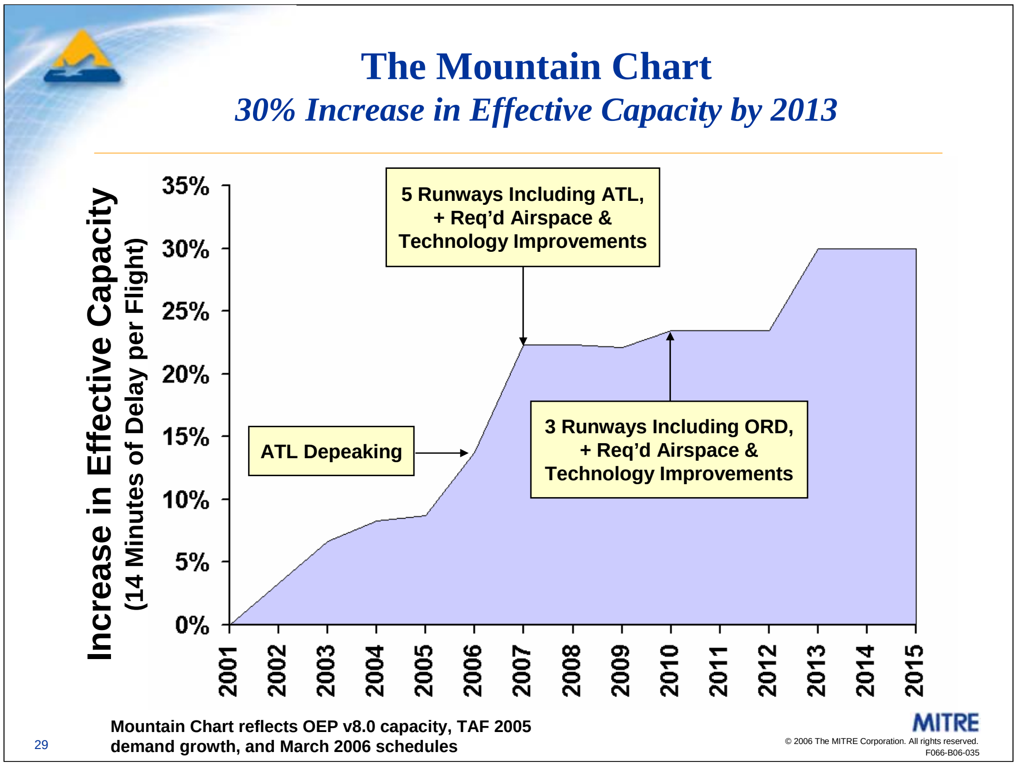
For the purpose of this analysis, all benefits are assumed to be realized in the year ***following*** implementation. For example, a runway added in FY2006 will show an improvement in Effective Capacity in 2007. This allows ample time for the improvement to be fully operational, controller familiarity and training to be completed, and regular operating procedures to be formalized.



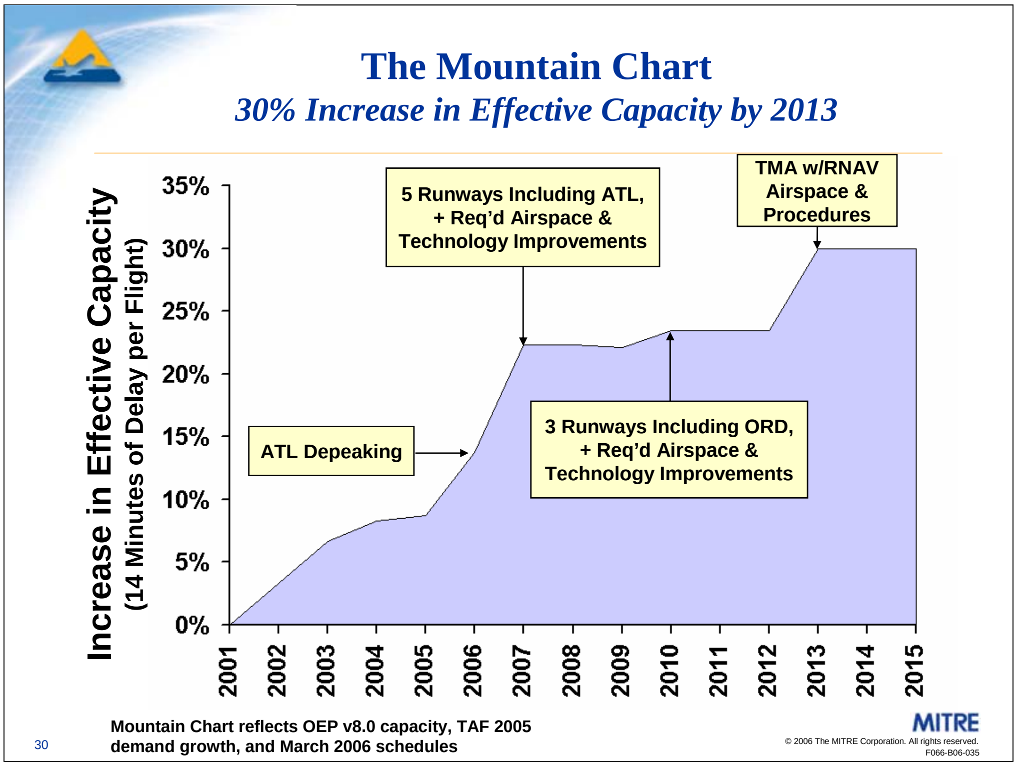
Effective capacity has already increased by about 13 percent since 2001. Depeaking at ATL has contributed significantly to the effective capacity increase in FY2006.



Five new runways, including one in ATL, as well as the required airspace and technologies to support these runways, will contribute to a significant gain in Effective Capacity in FY2007.



Effective capacity gains are also expected by 2010 with an additional runway at ORD and two other airports. In addition, airspace and technology improvements required to support these runway will also be in place.



Finally, significant capacity gains are expected when TMA and RNAV airspace and procedures are in place at all 35 OEP airports, achieving an effective capacity gain of 30 percent by 2013.

Summary

- OEP improvements are needed to keep the system operating with acceptable levels of delay
  - Planned OEP improvements are expected to keep delays about the same in 2015 as they were in 2000 (could range from 11 to 18 minutes)
- Five airports (EWR, FLL, LAS, PHL, and TPA) are expected to have high delays in 2015 even if demand does not grow as quickly as expected
- Effective capacity has increased by about 13% since 2000, and will grow to 30% by 2013
- Efforts must continue to be made to implement improvements that will improve system performance
  - Enable improved performance in Instrument Meteorological Conditions (IMC)
  - Relieve delays at heavily congested airports

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Glossary

ASPM	Aviation System Performance Measurements
ATL	Hartsfield-Jackson Atlanta International Airport
BOS	Boston-Logan International Airport
BWI	Baltimore/Washington International Thurgood Marshall Airport
CLE	Cleveland Hopkins International Airport
CLT	Charlotte/Douglas International Airport
CVG	Cincinnati/Northern Kentucky International Airport
DCA	Ronald Reagan Washington National Airport
DEN	Denver International Airport
DFW	Dallas/Fort Worth International Airport
DTW	Detroit Metropolitan Wayne County Airport
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
FLL	Fort Lauderdale-Hollywood International Airport
FY	Fiscal Year
HNL	Honolulu International Airport
IAD	Washington Dulles International Airport
IAH	Houston George Bush Intercontinental Airport
IMC	Instrument Meteorological Conditions
JFK	New York John F. Kennedy International Airport
LAS	Las Vegas McCarran International Airport
LAX	Los Angeles International Airport
LGA	New York LaGuardia Airport
MCO	Orlando International Airport
MDW	Chicago Midway International Airport
MEM	Memphis International Airport
MIA	Miami International Airport
MSP	Minneapolis-St. Paul International Airport
NAS	National Airspace System
OEP	Operational Evolution Plan
OPSNET	Operations Network
ORD	Chicago O’Hare International Airport
PDX	Portland International Airport
PHL	Philadelphia International Airport
PHX	Phoenix Sky Harbor International Airport
PIT	Greater Pittsburgh International Airport
RNAV	Area Navigation
SAN	San Diego International-Lindbergh Field Airport
SEA	Seattle-Tacoma International Airport
SFO	San Francisco International Airport
SLC	Salt Lake City International Airport
STL	Lambert-St. Louis International Airport
TAF	Terminal Area Forecast
TMA	Traffic Management Advisor
TPA	Tampa International Airport

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Glossary of Air Route Traffic Control Center Acronyms

ZAB	Albuquerque
ZAU	Chicago
ZBW	Boston
ZDC	Washington DC
ZDV	Denver
ZFW	Fort Worth
ZHU	Houston
ZID	Indianapolis
ZJX	Jacksonville
ZKC	Kansas City
ZLA	Los Angeles
ZLC	Salt Lake City
ZMA	Miami
ZME	Memphis
ZMP	Minneapolis
ZNY	New York
ZOA	Oakland
ZOB	Cleveland
ZSE	Seattle
ZTL	Atlanta